Ski Area Erosion Control Via Multi-Stakeholder Collaboration

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Sierra Business Council

Community-based planning

Sustainable economies

Conservation

Leadership

- Pioneering and demonstrating innovative approaches and solutions that foster community vitality, environmental quality, economic prosperity, and social fairness in the Sierra Nevada.

Sustaining The Sierra

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CAREC

California

Alpine

Resort

Environmental

Cooperative

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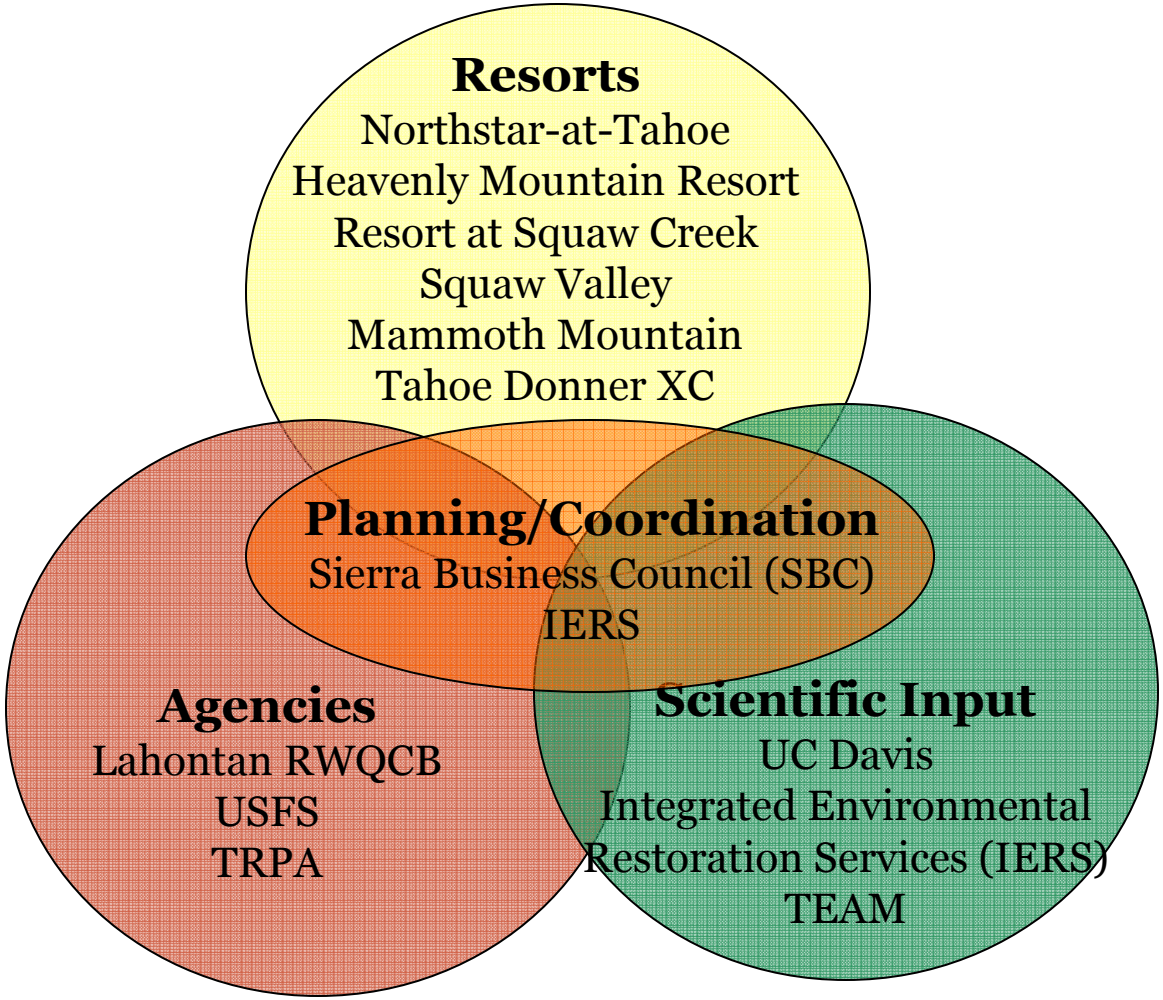
CAREC: Who are the participants?



Participating Resorts

Mammoth

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Participating Resorts

Mammoth

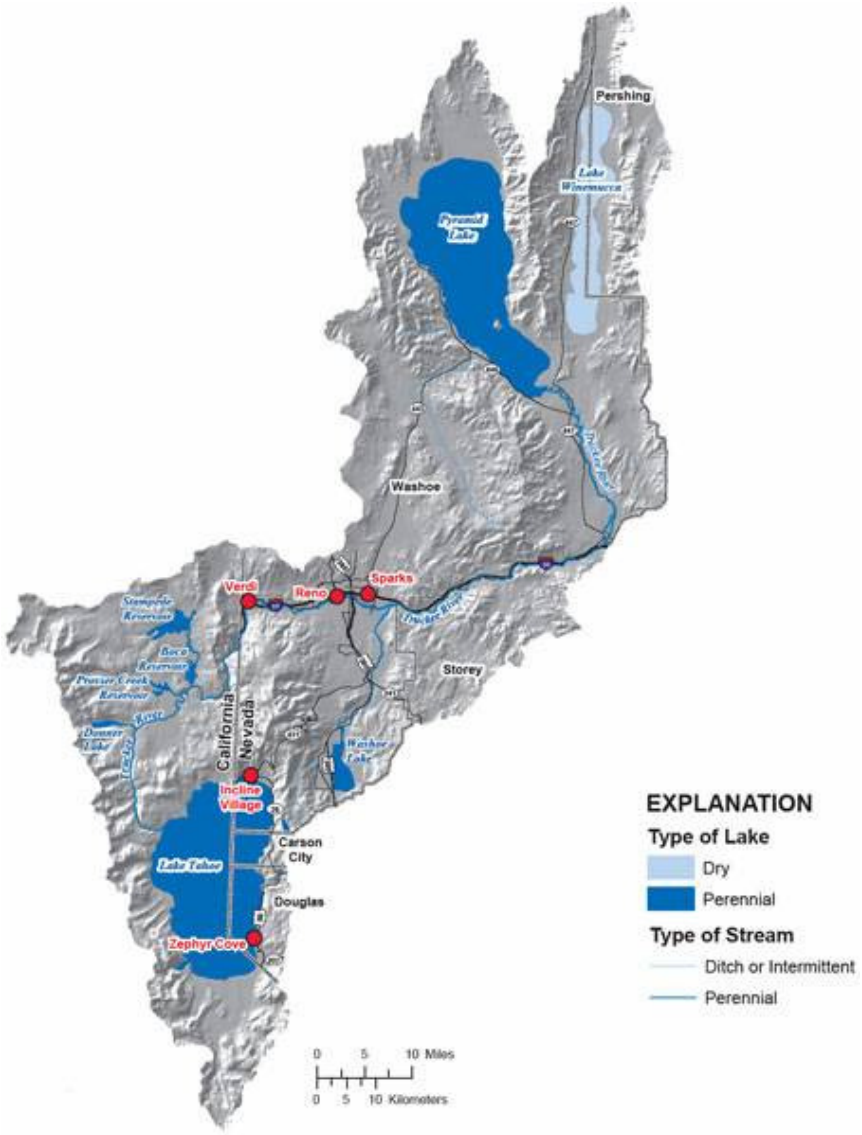
Heavenly

Squaw Valley

Resort at Squaw Creek

Tahoe Donner XC

Northstar



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Ski Areas & Sediment

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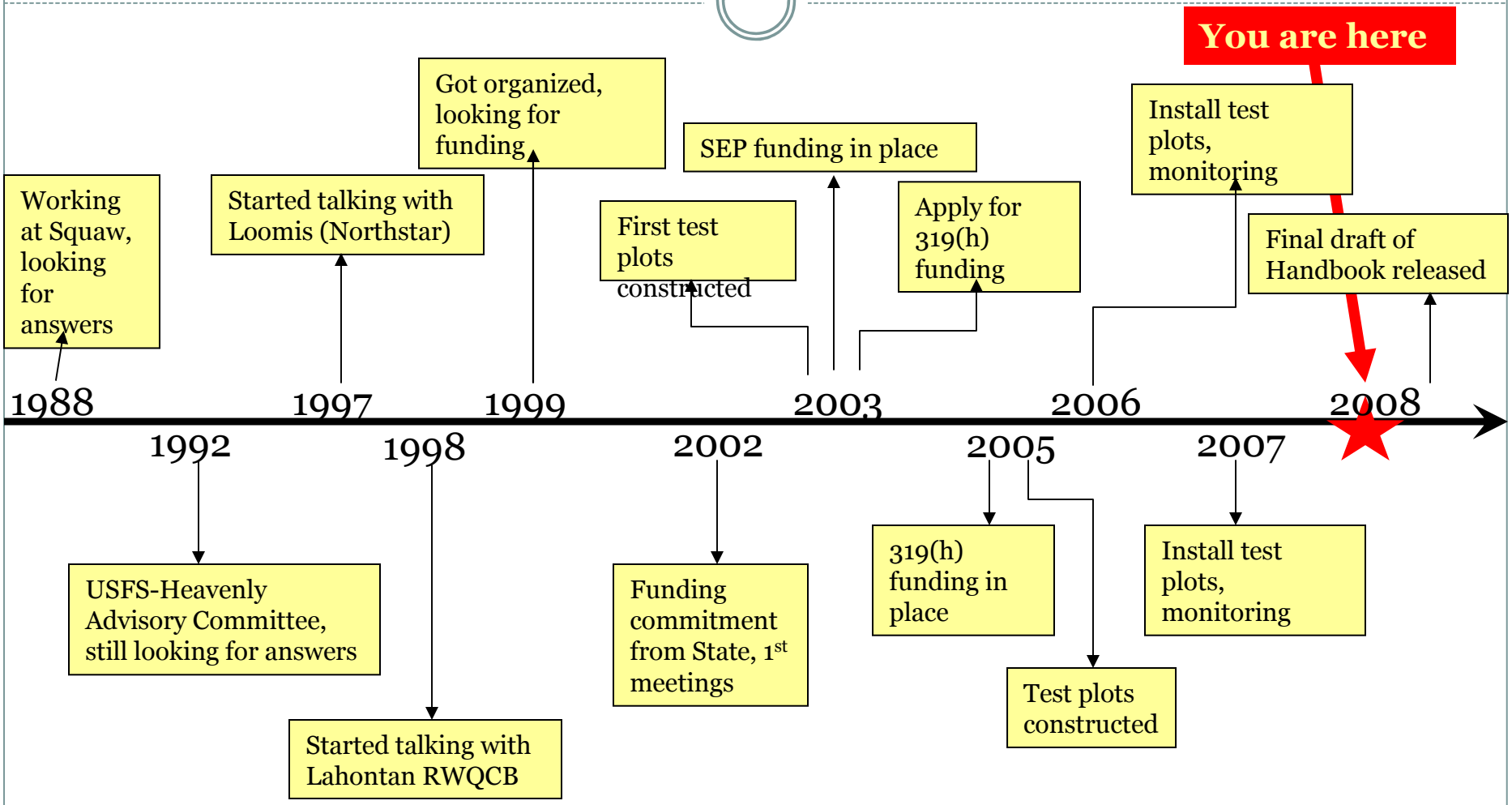
CAREC – past, present and future…



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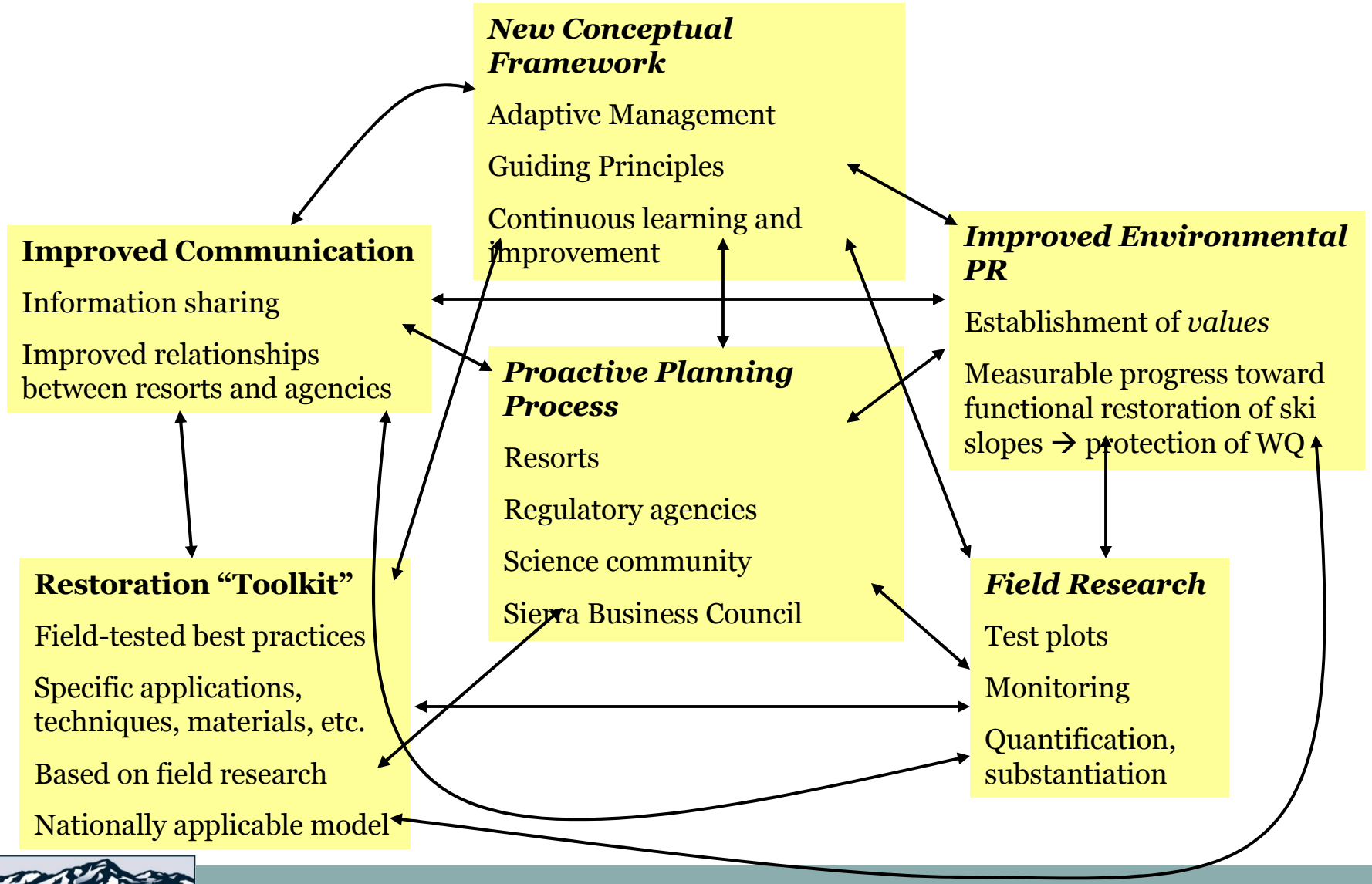
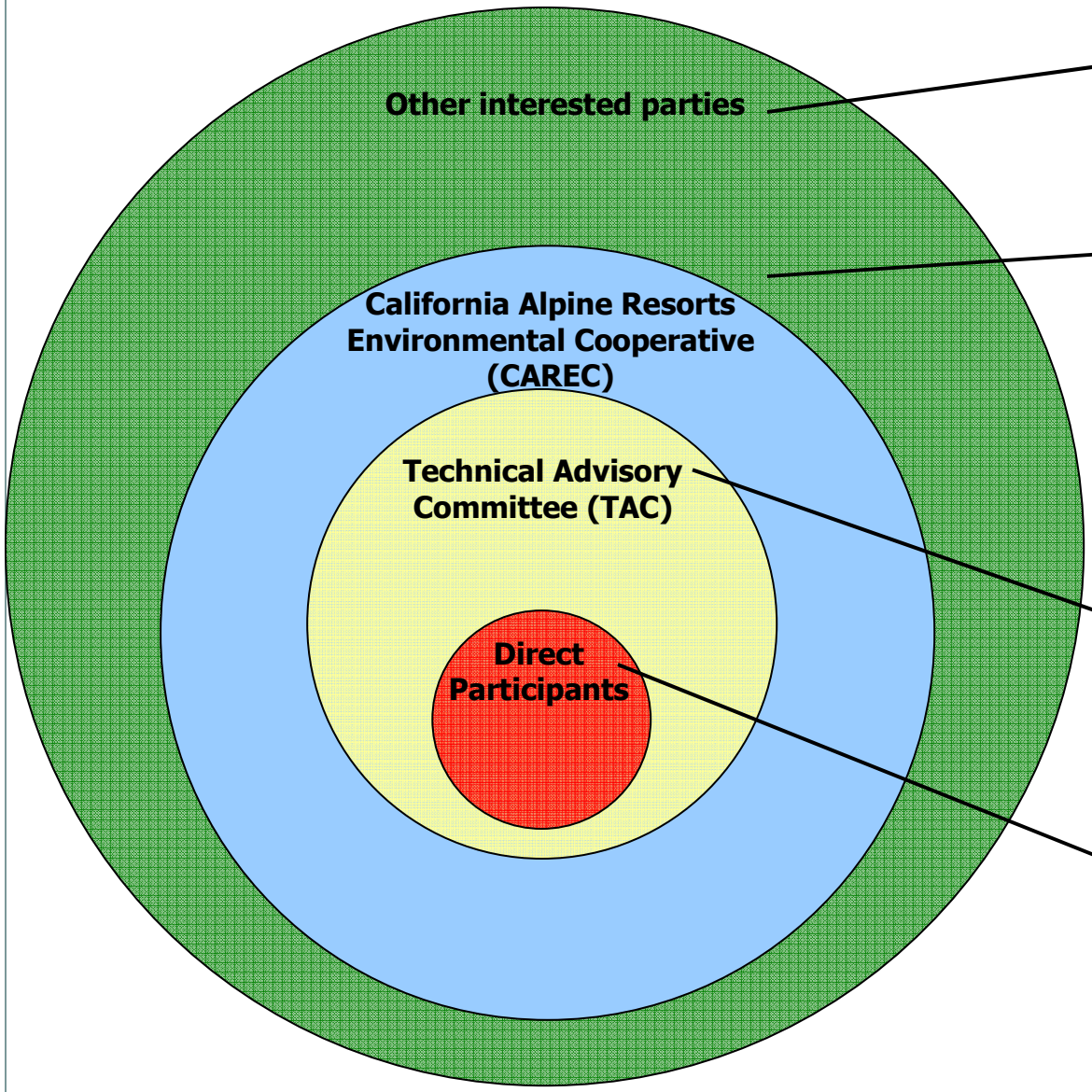
What is CAREC?



Levels of Involvement



Roles, Expectations

Will be kept in the loop via email updates, newsletters, press releases

Larger group of program stakeholders

Will be invited to annual or semi-annual meetings

Key players plus LRWQCB, USFS, TRPA, TEAM, etc.

Attend regular meetings

Provide technical and operational input

Review draft findings, handbook

Resorts, IERS, SBC,

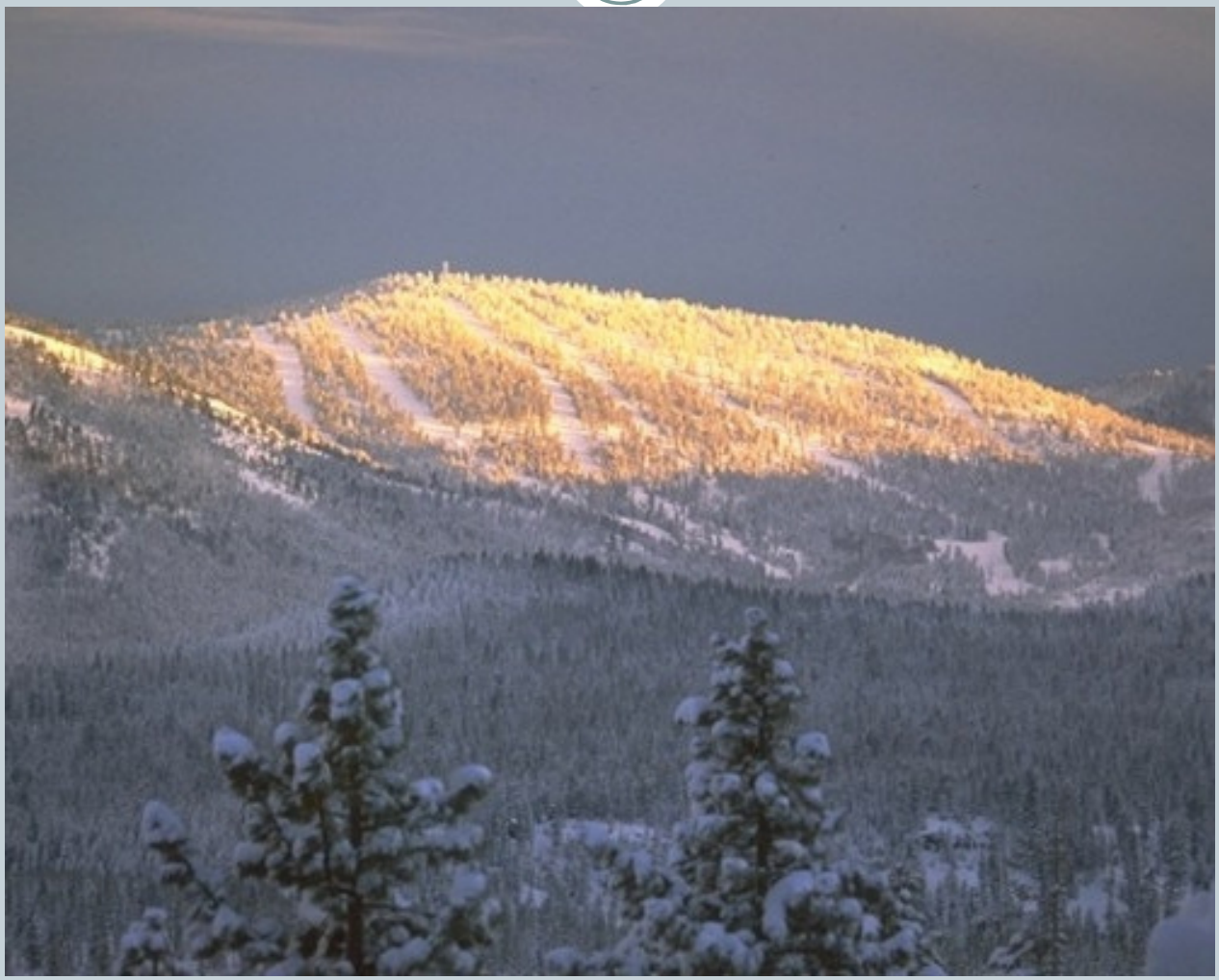
Install test plots, monitoring, reporting

Provide and document in-kind contributions (resorts)

Why CAREC?

Background	Outcomes
Longstanding reactive and adversarial relationship between ski resorts and agencies	Proactive and cooperative working relationship between ski resorts and agencies that is guided by adaptive management
Research gaps – need to conduct targeted research and quantify results	Data from field research is feeding into the development of best practices ("Toolkit") and help calibrate hydrologic models used in regional planning efforts
Ski areas have been identified as potential sources of sediment/erosion	Proactive efforts by ski areas to control erosion and protect water quality are widely recognized by citizens, agencies and environmental advocacy groups
Several concurrent/complimentary regional planning efforts are underway • Pathway 2007 • TMDL planning	CAREC is able to strengthen Pathway 2007 and TMDL planning processes by providing much-needed data and forging new public-private partnerships

Stop thinking about lunch… keep thinking about skiing…



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Field Process

- Develop test plot questions
- Select site(s) for test plots

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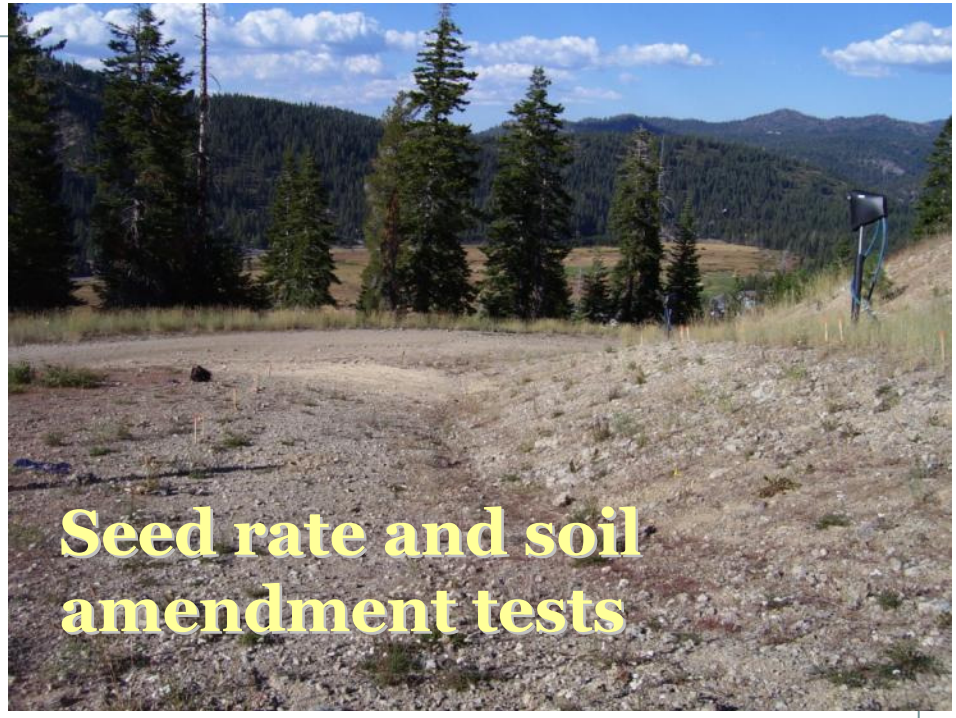
Soil amendment additions, infiltration treatments


Seed rate and soil amendment tests


Drainage systems and soil amendments


Stabilizing ultra-steep slopes

Field Process

- Develop test plot questions
- Select site(s) for test plots
- ***Pre-treatment monitoring***

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Field Process

- Develop test plot questions
- Select site(s) for test plots
- Pre-treatment monitoring
- ***Install test plots***

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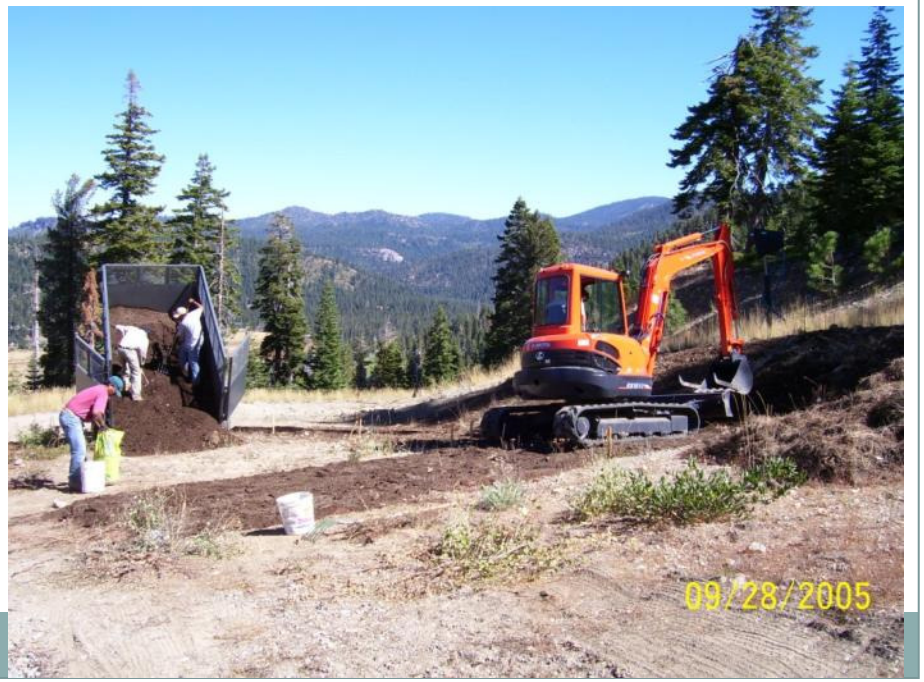
CAT
CAT


09/28/2005

Field Process

- Develop test plot questions
- Select site(s) for test plots
- Pre-treatment monitoring
- Install test plots
- ***Monitoring for several years***

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Test Plot Questions

- Seed rates, seed mixes (grass, shrub, forb)
- Seeding vs. planting
- Irrigation vs. no irrigation (frequency, intensity, duration)
- Amendments - wood chips, compost, aged wood chips
- Biosol rates
- Stabilizing steep slopes – tilling, drilling, "poke and wiggle"
- Tilling vs. ripping → recompaction over time, infiltration rates
- Mulch types – wood chips vs. pine needles
- Road design → designing for sediment source control
- Water routing and drainage system design

Integrated
Environmental Restoration Services, Inc.

Northstar-at-Tahoe
Bearpaw Tilling Depth Test Plots
As-Built Report

Project Location: Bearpaw ski run, Northstar-at-Tahoe, Truckee, CA

Personnel: Kevin Drake (IERS), Lorenzo Worster (IERS), IERS hand crew

Dates: 8/17/05 – 8/25/05

Site Description: The test plots are located at Northstar Ski Resort on Bearpaw ski run, just south of (and parallel to) the Bearpaw lift. The test plots are situated along an area that was disturbed during the replacement of a waterline. At the time of test plot construction, there was no remaining vegetation or topsoil along the waterline and the soil was highly compacted.

Problem Statement: Controversy exists regarding which depth to till soil. By tilling to various depths, we may be able to determine whether one tilling depth provides an advantage when compared to another in terms of water holding capacity, nutrient availability, runoff, etc.

Research Question:

1. What effect does different tilling depth have on soil infiltration capacity and water holding capacity?
2. Does tilling depth affect soil nutrient availability and/or seed response?
3. How does soil density/compaction change over time when soil is tilled to different depths?

Design: Six test plots were constructed, each 4m x 9m. Plots were individually tilled to one of three depths – 6", 12" and 18" (see map). All other variables were held constant.

Measurables: Penetrometer, rainfall and runoff simulation, plant response, species mix

Soil Samples: Four soil samples were taken from areas around and near the test plots (see map for specific locations). For each sample, three sub-samples were taken from depths ranging from 0 – 30 cm and then composited. Two control samples (NSBC1 and NSBC2) were taken just above and below the test plots. These control samples should be considered representative of pre-treatment soil conditions in the test plot area. Two reference samples were also taken. One sample (NSBR1) was taken from a well vegetated area that had ~ 4-5" of fungi-covered woodchips on the ground, just beneath the Bearpaw lift line. The other reference sample (NSBR2) was taken in a narrow forested area nearby that had no evidence of recent disturbance.

Treatment Description:

- **Compost:** Northstar compost (produced onsite) was applied to the surface of all plots to a depth of 3". Compost was then incorporated into the soil with an excavator during tilling. This compost had a high percentage of woody material. No samples of Northstar's compost have been tested for nutrient content this year.
- **Tilling:** Tilling was done using an excavator with an experienced operator and IERS personnel on the ground checking tilling depths regularly with a cone penetrometer. Following tilling of all plots, additional penetrometer measurements were taken to determine actual tilling depths. For each plot, penetrometer measurements were taken along four transects with 7 points each for a total of 28 points per plot.

Table 1: Comparison of specified tilling depths to mean penetrometer depths following tilling.

Plot	Specified Depth (in.)	Mean Depth (in.)	Standard Deviation	Coefficient of Variation
1A	18	16.1	3.82	0.24
1B	6	7.7	1.92	0.25
2A	12	12.6	2.13	0.17
2B	18	16.5	3.19	0.19
3A	6	7.5	1.86	0.25
3B	12	12.3	2.12	0.17

- **Fertilizer:** Biosol organic fertilizer (7-2-3) was hand-cast onto the surface of all plots at a bulk rate of approximately 2000 lbs/acre then raked into the soil.
- **Seed:** A total of 9 lbs PLS of native grass seed mix was applied to all test plots at a rate of ~180 lbs/acre. The seed mix consisted of California Brome (*Bromus Carinatus*, 43.0%), Blue Wild Rye (*Elymus glaucus*, 32.4%) and Squirreltail (*Elymus elymoides*, 21.7%). Following application, the seed was lightly raked in to the soil using the flat side of a rake.
- **Mulch:** Approximately 12 cubic yards of pine needle mulch was applied to the plots to an average depth of 2".

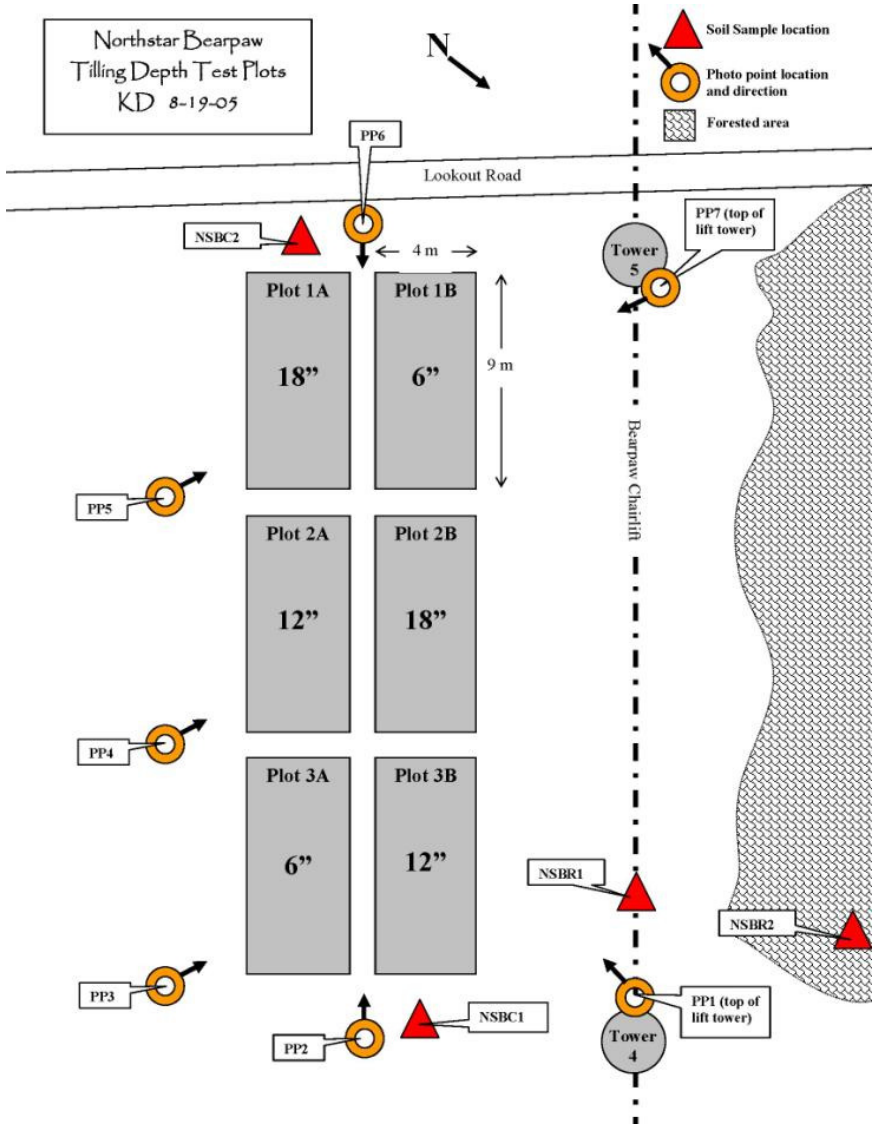
Summary of Daily Activities:

- August 17th, 2005 – Compost was applied to all plots and raked to a depth of 3". An excavator was used to incorporate compost and till each plot to the specified depth.
- August 19th, 2005 – Large rocks on the surface were removed and used to delineate the test plots. Biosol (7-2-3) was applied to all plots then raked into the soil. Penetrometer measurements were then taken to determine the actual depth of tilling attained at each plot (see Table 1).
- August 24th, 2005 – All plots were seeded and mulched.
- August 25th, 2005 – Pine needle mulch was spread on areas around test plots that were disturbed during the staging of materials.

Notes: Following tilling of plots 2A and 2B, it was observed that some of the rocks had charcoal on the surface, suggesting that fire my have burned in this area. Later, small pieces of burned wood were also found on the surface of the same test plots. This should be considered during analysis of test plot results.

The excavator operator indicated that took no longer to till to 18" than it did to till to 6". The only challenge with deeper tilling was that more rocks were turned up. When possible, rocks were rolled into nearby depressions or tapped down into the soil using the excavator bucket rather than being removed. This method was effective at keeping most of the rocks from exceeding 6" of relief (a primary concern of ski resort management) and was more efficient that removing rocks individually.

Test Plot Construction Photos



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Monitoring

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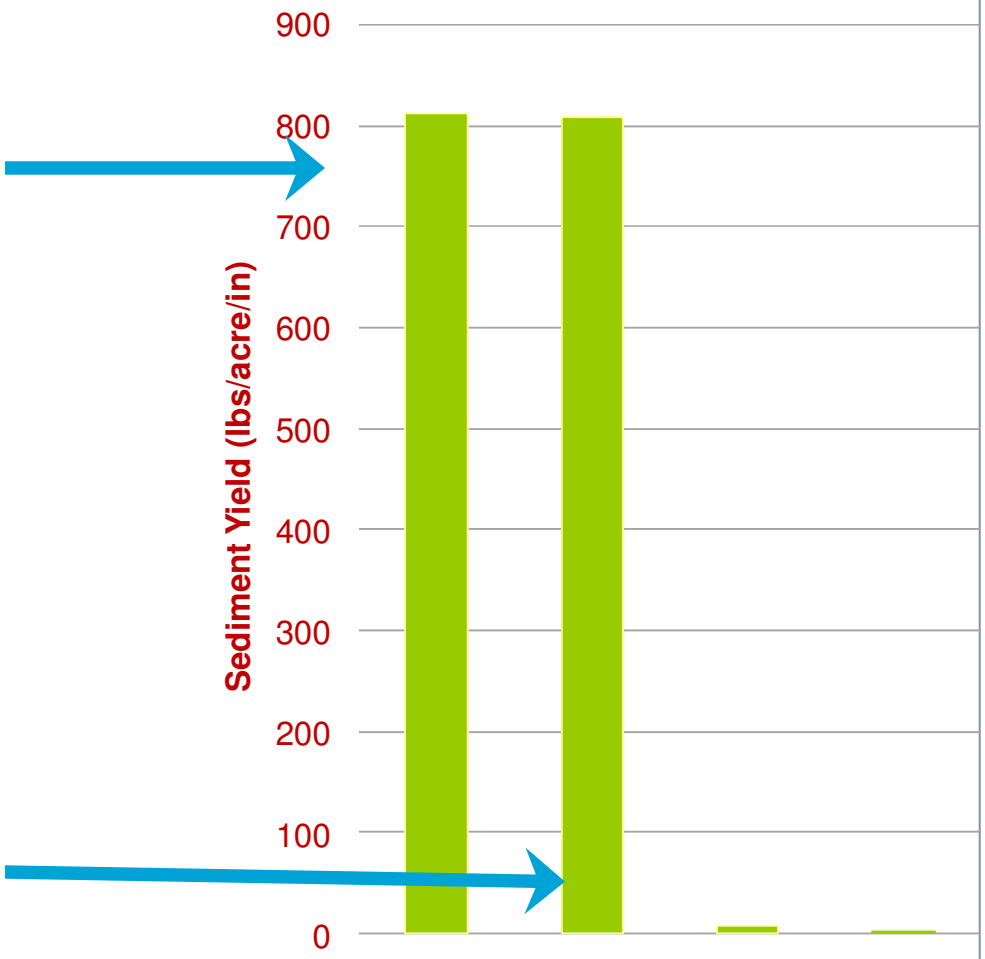
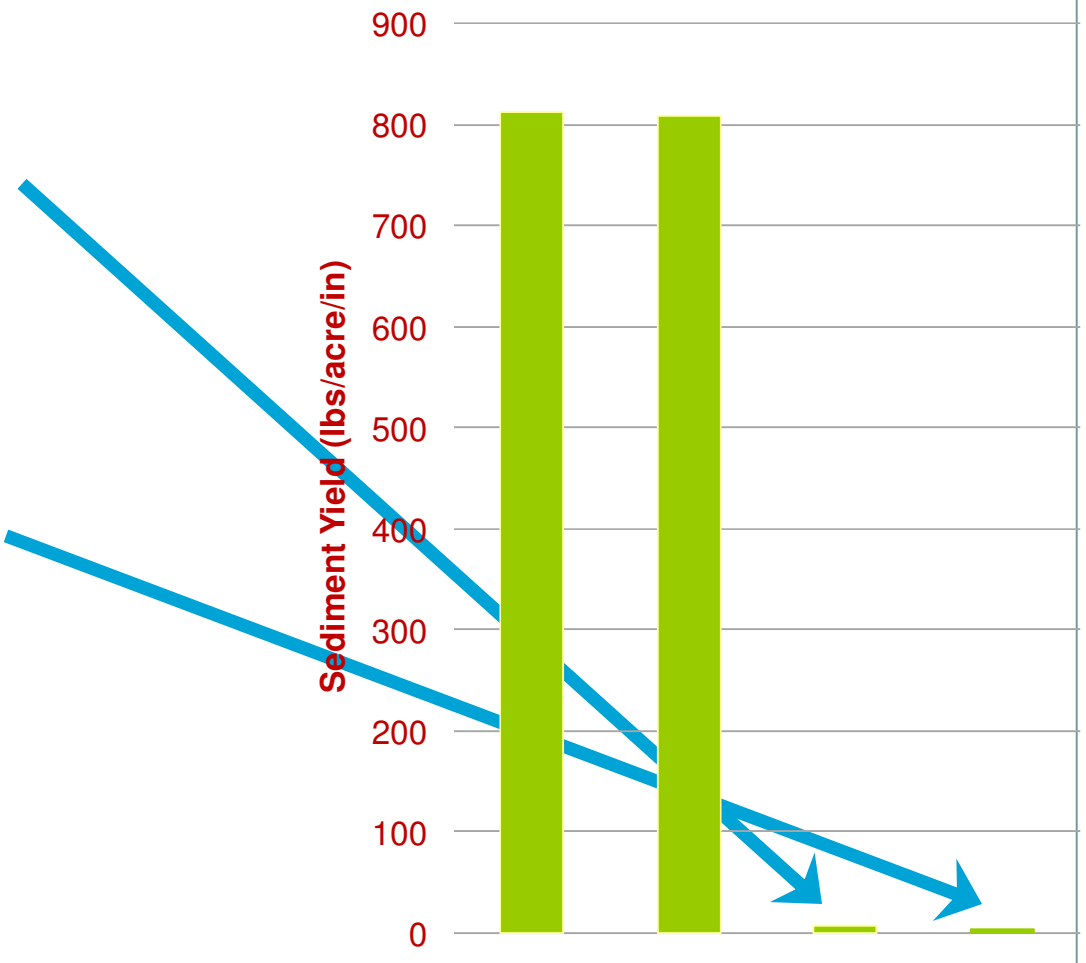
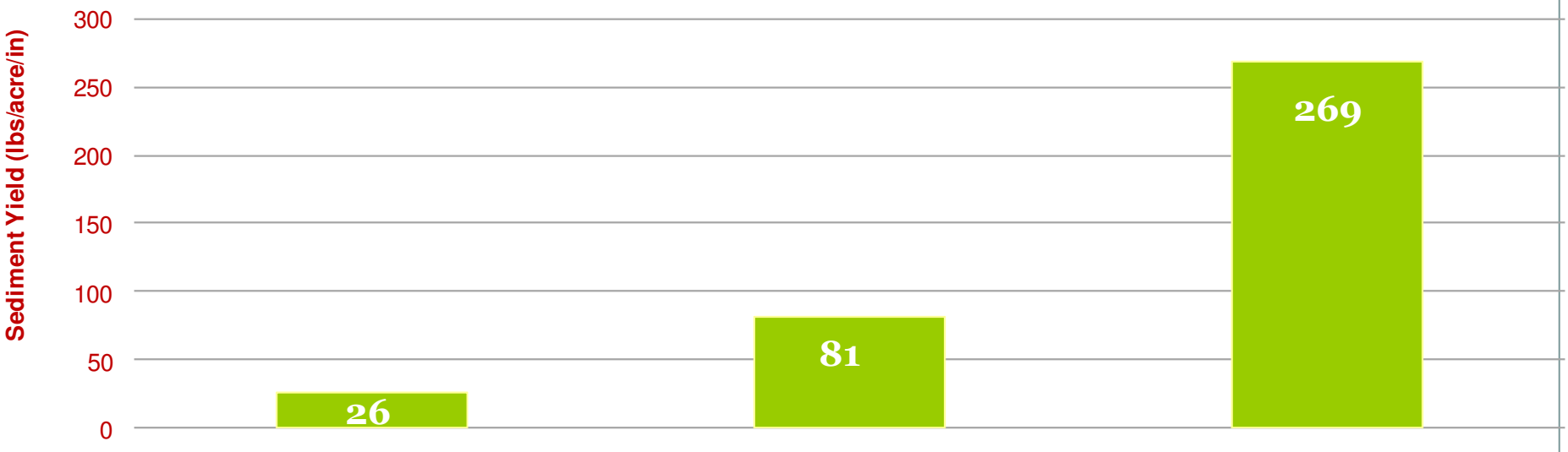
Vegetation cover and sediment yield



Vegetation cover and sediment yield



Mulch cover and sediment yield



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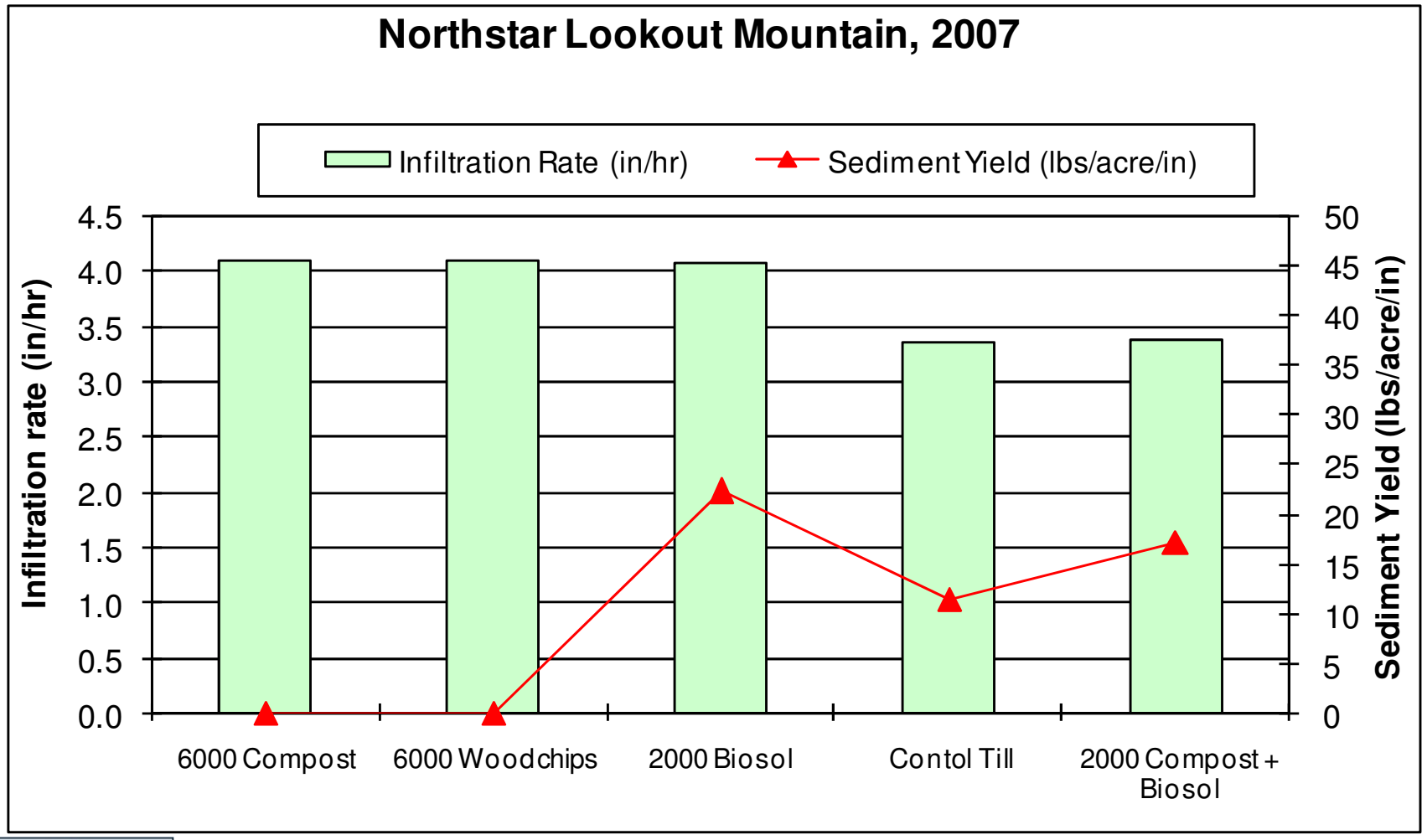
Long-term results



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Dominant species and soil moisture

Squirreltail

Blue Wildrye

Low

Soil Moisture

High

Needlegrass

Mountain Brome

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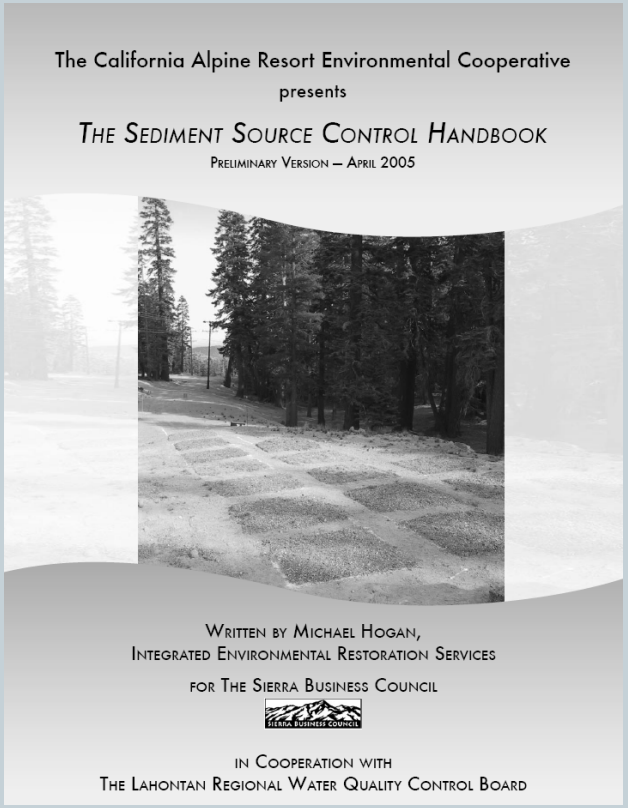
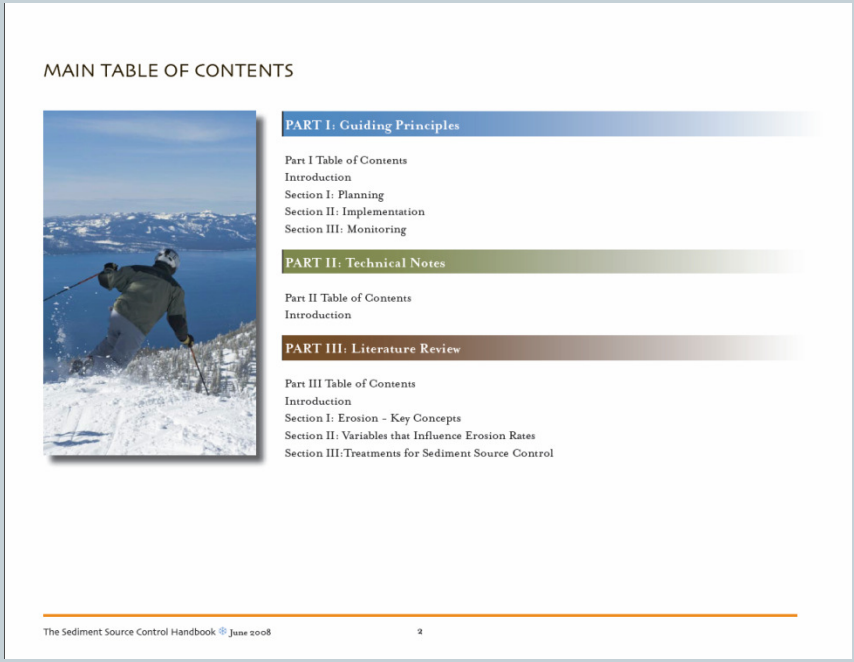
Sediment Source Control Handbook

2005 Draft Handbook



2008 Final Handbook (still a work in progress)



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http://www.swrcb.ca.gov/lahontan/water_issues/available_documents/carec.shtml

Barriers in implementing NPS pollution controls & measuring associated improvements

- Lack of agency coordination
- Poor communication at implementation sites
- Short period of monitoring funding
- Reactive regulation = frustration, poor communication & dysfunctional relationships

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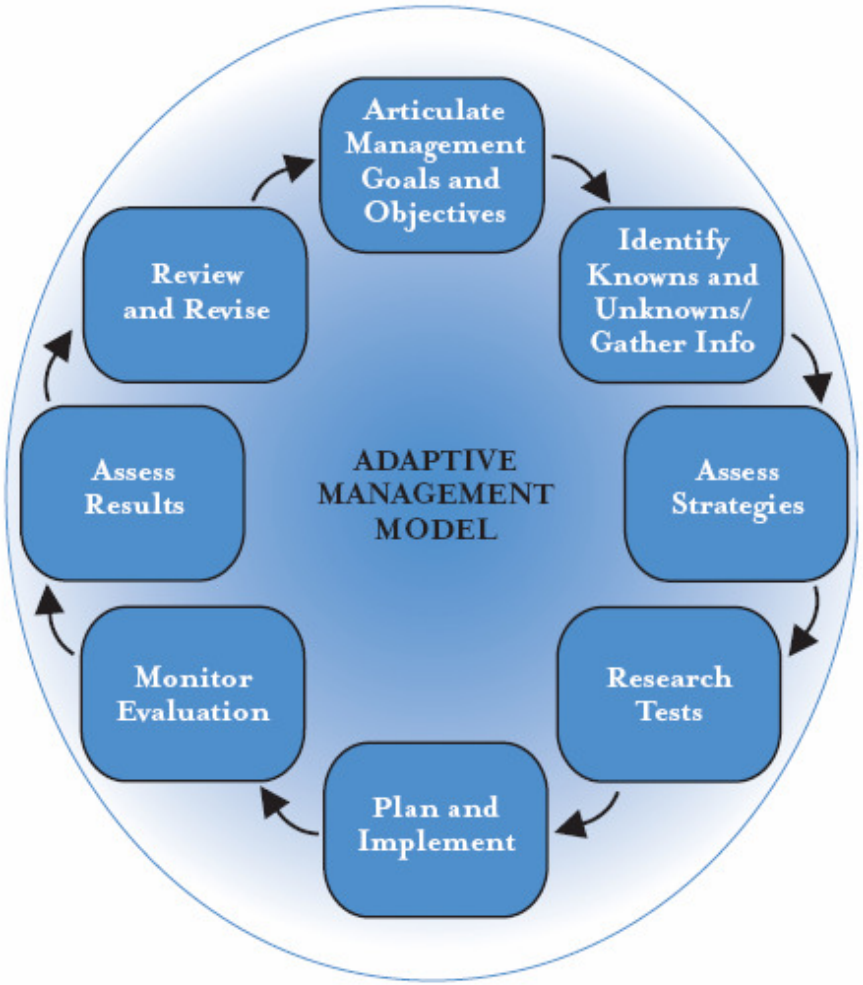
Keys to success

- Get ALL the players at the table in the beginning.
- Monitor
- Be flexible & proactive… adaptive management
- Monitor
- Monitor!



Thank you!

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